

60500
Soil
702.46 grams

Introduction

60500 was collected adjacent to drive tube 60010/60009, about 100 m from the LM. The rake sample, 60510, from the same area did not contain many rock fragments on the surface and came up nearly empty. The sieved portion of 60500 did not include any walnut sized rocks (> 1 cm), while 60510 included only 11 small rake samples (table 2). However, a large portion of 60500 remains unsieved.

Petrography

60500 is a mature soil with a maturity index of $Is/FeO = 80$ (Morris 1978). Graf (1993) reported the grain size distribution (figure 6).

Kempa et al. (1980) calculated that 60500 was $\sim 55\%$ anorthosite, $\sim 30\%$ impact melt and $\sim 10\%$ mare component.

The Apollo Soil Survey (Ridley et al. 1973) analyzed a large number of the glass particles in 60501, grouping them by clusters in composition diagrams (figures 4 and 5). They found about $\sim 45\%$ were ‘highland basalt’, while about $\sim 8\%$ were mare basalt. Highland basalt may not be a distinct rock type, but rather a glass made from highland soil (Meyer et al. 1974).

Glass splashed on rocks is a common feature at Apollo 16 (See et al. 1986; Morris et al. 1986) and seems to be derived from melted soils. Figure 2 and table 3 give the composition of a glass coat on 60527.

Rake samples

Eleven small rake samples were collected (figures 7, 8 and 9) from the same location (table 2). Both anorthosites and impact melt rocks were included (table 3).

Chemistry

Soil sample 60501 has been well analyzed by numerous investigators (table 1). The composition is similar to other lunar soils (figures 1 and 3). The soil is high in meteoritic siderophiles (Ni, Ir and Au). Muller (1973) determined 81 ppm nitrogen, standard for mature soil.

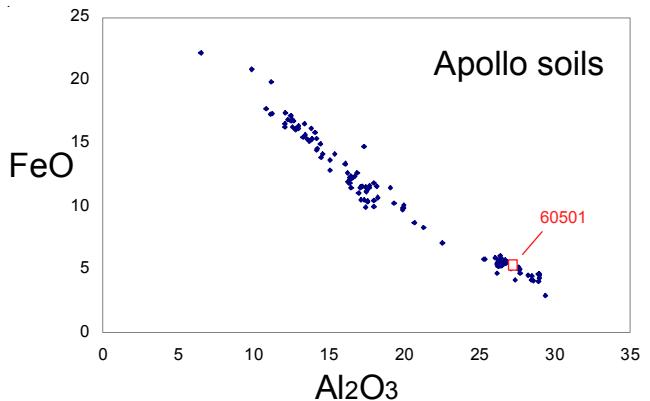


Figure 1: Chemical composition of Apollo soils including 60500.

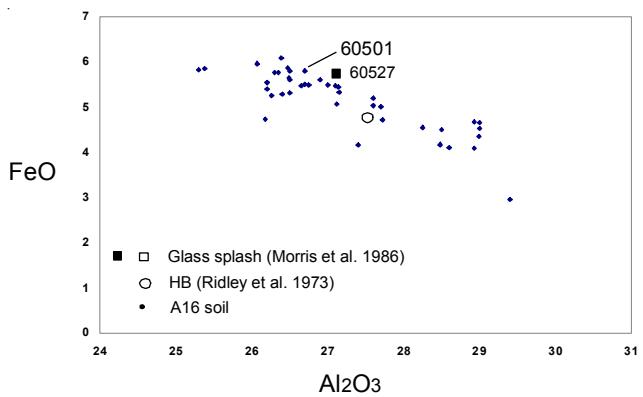


Figure 2: Composition of Apollo 16 soils with that of glass splash on 60527 and ‘highland basalt’ (HB).

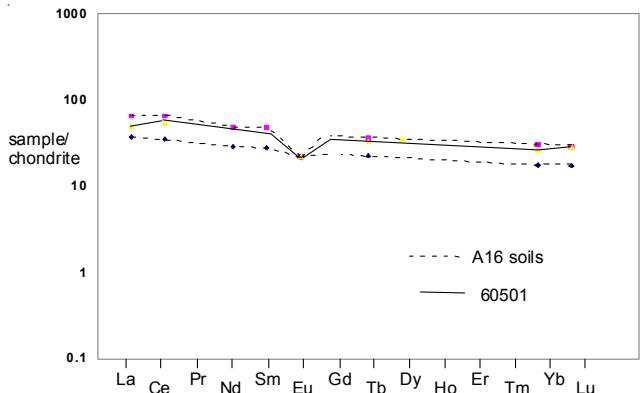


Figure 3: Normalized rare-earth-element diagram for Apollo 16 soils with 60501 shown.

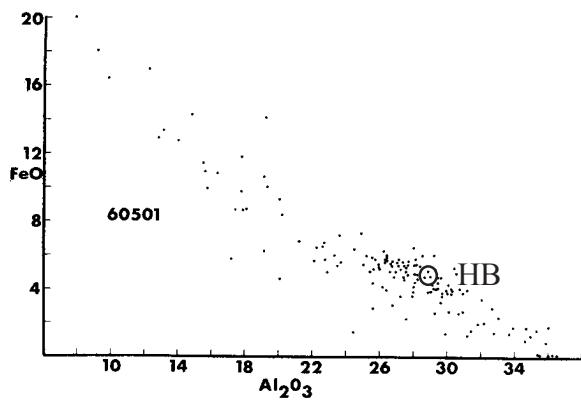


Fig. 4. FeO–Al₂O₃ wt.% plot for glasses in soil 60501.

Ridley et al. 1973

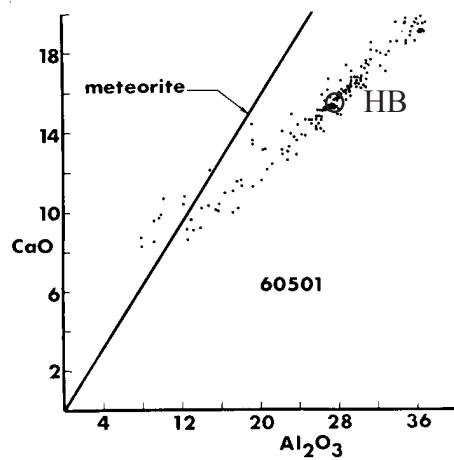


Figure 5: Composition of glass particles found in 60501 by Ridley et al. 1973. The symbol HB is the average of a cluster of glass compositions termed 'highland basalt' by Ridley et al.

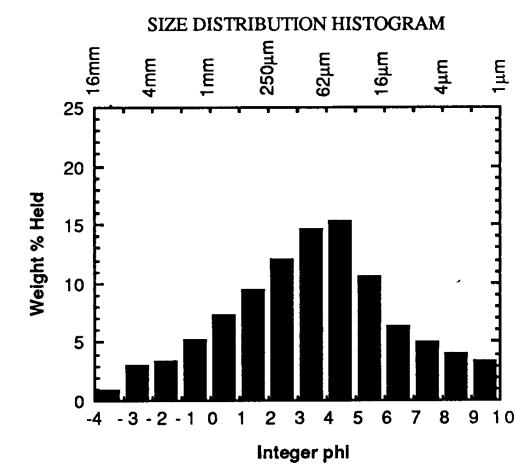
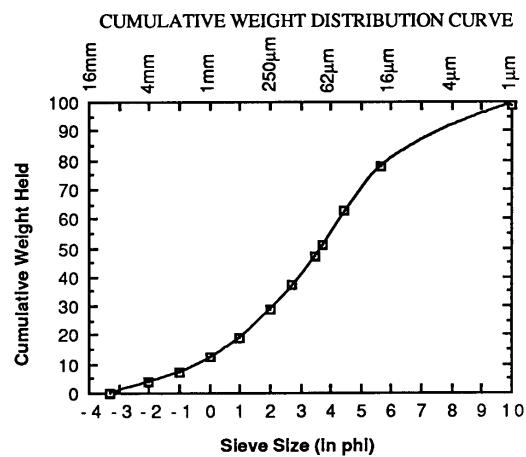


Figure 6: Grain size distribution for particles in 60501 reported by Graf 1993.

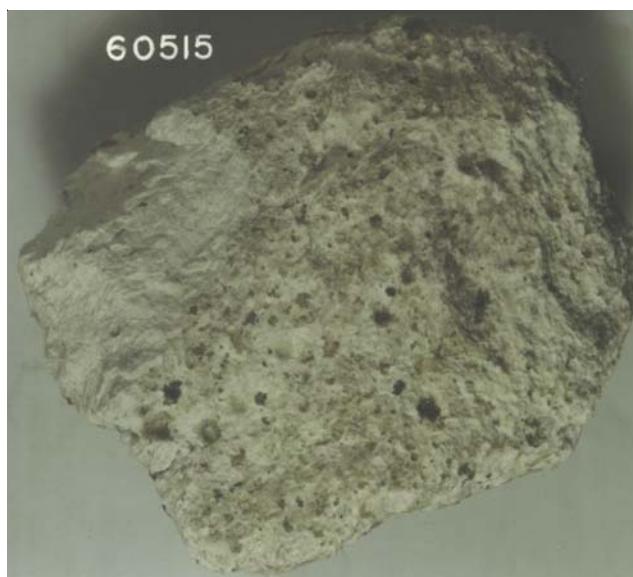


Figure 7: Photo of rake sample 60515. S72-46333



Figure 8: Photo of 60527. S-72-46328

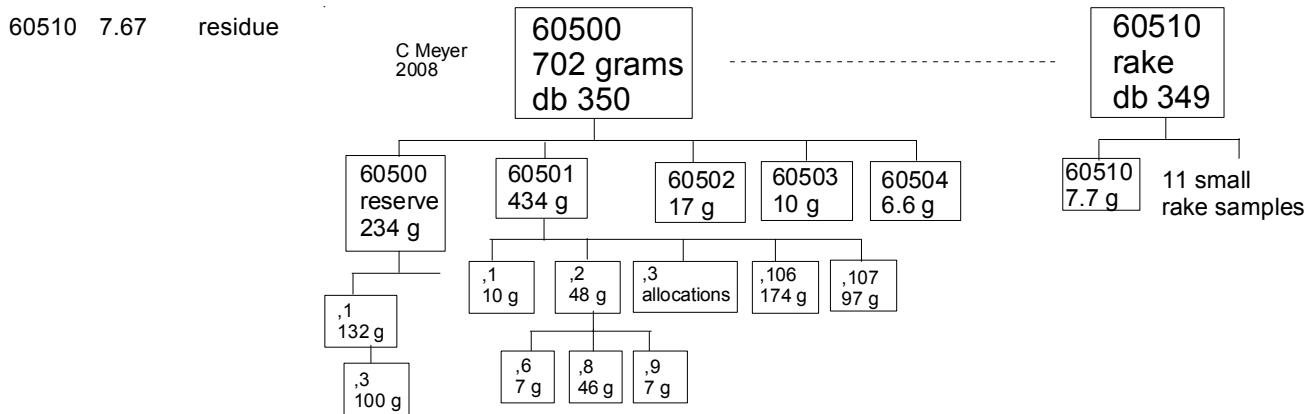
Table 1. Chemical composition of 60500.

reference weight	Duncan73 fines	Rose75 coarse	Morrison73	Muller75	Finkelman75 fines	Boynton75 314 ng	Baedecker72	Compston73	Fruchter74
SiO ₂ %	45.22 (a)	44.95	45.44 (b)					45.17 (a)	
TiO ₂	0.59 (a)	0.6	0.61 (b)	0.63 (c)		0.6 (d)		0.59 (a)	
Al ₂ O ₃	26.84 (a)	26.45	25.54 (b)	25.5 (c)	26.6		26.4 (d)	26.71 (a)	27.4 (d)
FeO	5.51 (a)	5.38	5.46 (b)	5.45 (c)	5.7		6.05 (d)	5.57 (a)	5.15 (d)
MnO	0.072 (a)	0.08	0.07 (b)	0.067 (c)		0.076 (d)		0.08 (a)	
MgO	5.52 (a)	6.05	6.43 (b)	6.58 (c)	6.38		6.03 (d)	6.03 (a)	
CaO	15.32 (a)	15.42	15.39 (b)	15.8 (c)	15.5		16.1 (d)	15.61 (a)	
Na ₂ O	0.4 (a)	0.44	0.45 (b)	0.44 (c)	0.53	Clark 73	0.5 (d)	0.44 (a)	0.3 (d)
K ₂ O	0.114 (a)	0.13	0.12 (b)	0.1 (c)	0.12	0.12 (e)		0.12 (a)	
P ₂ O ₅	0.137 (a)	0.12	0.11 (b)	0.064 (c)				0.12 (a)	
S %	0.065 (a)			0.048 (c)					
<i>sum</i>									
Sc ppm		11	8.8 (b)	10.1 (c)		8.8	11 (d)	9.5 (d)	
V		23	14 (b)	17 (c)		14	23 (d)		10.1 (d)
Cr		752	958 (b)	710 (c)			710 (d)		774 (d)
Co		30	37 (b)	30 (c)		37	30 (d)	59	29 (d)
Ni	321 (a)	618	720 (b)	418 (c)		700	618 (d)	495	(d)
Cu	4.8 (a)	17	15 (b)	7.7 (c)		15	17 (d)		
Zn	21.6 (a)	29	16 (b)	22 (c)		16	29 (d)	23	(d)
Ga		4.3	3.5 (b)	3.6 (c)		3.5	4.3 (d)	5.1	(d)
Ge ppb							1250	(d)	
As									
Se									
Rb	2.9 (a)	3.6	2.8 (b)	2.6 (c)	3.5	2.8	3.6 (d)		2.8
Sr	165 (a)	126	121 (b)	158 (c)	163	121	126 (d)		168
Y	41 (a)	58	42 (b)	50 (c)		42	58 (d)		
Zr	192 (a)	196	166 (b)	210 (c)		166	196 (d)		
Nb	12.1 (a)	15	10 (b)	13 (c)		10	15 (d)		
Mo									
Ru									
Rh									
Pd ppb									
Ag ppb									
Cd ppb							102 (d)		
In ppb				80 (c)			13 (d)		
Sn ppb									
Sb ppb									
Te ppb									
Cs ppm			0.03 (b)	0.16 (c)					
Ba	149 (a)	161	143 (b)	210 (c)	141		130 (d)		140 (d)
La		10	10 (b)	11 (c)	12.7		11.6 (d)		12.4 (d)
Ce			27 (b)	(c)			33 (d)		31.5 (d)
Pr			4.7 (b)	(c)					
Nd			22 (b)	(c)				19 (d)	
Sm			6 (b)	(c)				6.2 (d)	
Eu			1.2 (b)	(c)		1.22 (d)		1.3 (d)	
Gd			5.5 (b)	(c)					
Tb			1.2 (b)	(c)		1.2 (d)			
Dy			7.1 (b)	(c)		8.6 (d)		1.2 (d)	
Ho			1.3 (b)	(c)					
Er			4.9 (b)	(c)					
Tm			0.52 (b)	(c)					
Yb	5.2	4.4 (b)	4.4 (c)			4.2 (d)		4.3 (d)	
Lu			0.65 (c)			0.7 (d)		0.7 (d)	
Hf			5.4 (c)			4.4 (d)		4.2 (d)	
Ta						0.53 (d)		0.5 (d)	
W ppb									
Re ppb									
Os ppb									
Ir ppb							17 (d)		
Pt ppb									
Au ppb					Clark 73		8 (d)		
Th ppm			2.4 (c)		2.2 (e)	2.2 (d)			2.3 (d)
U ppm			0.62 (c)	0.42	0.61 (e)				

technique: (a) XRF, (b) 'microchemical', (c) INAA, RNAA, SSMS, (d) INAA, RNAA, (e) radiation count.

Table 2: Rake Samples from 60510 (DB349)

	weight	Ryder's term	ref
60515	16.74	cataclastic anorthosite	Warren et al. 1983
60516	7.91	cataclastic anorthosite	Dowty et al. 1974
60517	1.23	cataclastic anorthosite	
60518	1.12	cataclastic anorthosite	
60519	0.5	cataclastic anorthosite	
60525	12.84	poikilitic impact melt	Warner et al. 1976
60526	8.42	poikilitic impact melt	Warner et al. 1976
60527	7.36	crystalline breccia and vesicular glass	
60528	2.94	glassy impact melt	
60529	1.24	basaltic impact melt	
60535	7.23	regolith breccia	



Cosmogenic isotopes and exposure ages

Clark and Keith (1973) determined the cosmic-ray-induced activity of ^{26}Al = 107 dpm/kg., ^{22}Na = 42 dpm/kg., ^{54}Mn = 8 dpm/kg. and ^{56}Co = 10 dpm/kg. for 60501.

Other Studies

Bogard D.D. and Nyquist L.E. (1973) determined the rare gas content.

Table 3. Chemical composition of rake samples.

	60515 reference	Warren83	60516 Dowty 74	Ryder 80	60525 Warner 76	60526 Warner 76	60527 See86	Morris86	60527 glass
SiO ₂ %	43.2	44.8	(a)	46.1	(a)	47.5	(a)	45.57	46.27 (a)
TiO ₂	0.07			1.05	(a)	1.4	(a)	0.88	0.39 (a)
Al ₂ O ₃	35.3	35.2	(a)	21.2	(a)	17.4	(a)	26.92	18.88 (a)
FeO	0.77	0.28	(a)	7.2	(a)	8.9	(a)	5.37	6.64 (a)
MnO	0.0015			0.08	(a)	0.09	(a)	0.06	
MgO	0.33	(b)	0.05	(a)	9.3	(a)	13.5	(a)	5.43 13.95 (a)
CaO	19.2	(b)	19.2	(a)	12.9	(a)	10.8	(a)	15.21 12.93 (a)
Na ₂ O	0.42	(b)	0.44	(a)	0.64	(a)	0.71	(a)	0.57 0.31 (a)
K ₂ O	0.007	(b)	0.01	(a)	0.27	(a)	0.45	(a)	0.14 0.15 (a)
P ₂ O ₅				0.02	(a)	0.26	(a)	0.44	(a)
S %									
sum				100		100		100	
Sc ppm	2.03	(b)						10.23	(b)
V									
Cr	121	(b)						774	(b)
Co	1.7	(b)						20	(b)
Ni	8	(b)						317	(b)
Cu									
Zn	0.44	(b)							
Ga	4.2	(b)							
Ge ppb	4.2	(b)							
As									
Se									
Rb	2.7	(b)							
Sr	209	(b)							
Y									
Zr									
Nb									
Mo									
Ru									
Rh									
Pd ppb									
Ag ppb									
Cd ppb	29	(b)							
In ppb									
Sn ppb									
Sb ppb									
Te ppb									
Cs ppm									
Ba	13	(b)						196	(b)
La	0.28	(b)						13.85	(b)
Ce	0.74	(b)						43.8	(b)
Pr									
Nd									
Sm	0.124	(b)						6.57	(b)
Eu	0.92	(b)						0.94	(b)
Gd									
Tb	0.021	(b)						1.09	(b)
Dy									
Ho									
Er									
Tm									
Yb	0.067	(b)						4.54	(b)
Lu	0.014	(b)						0.63	(b)
Hf	0.1	(b)						4.07	(b)
Ta	0.037	(b)						0.87	(b)
W ppb									
Re ppb	0.006	(b)							
Os ppb									
Ir ppb	0.003	(b)							
Pt ppb									
Au ppb	0.0055	(b)							
Th ppm	0.023	(b)						2.08	(b)
U ppm	0.06	(b)						0.93	(b)

technique: (a) broad beam e. probe, (b) INAA

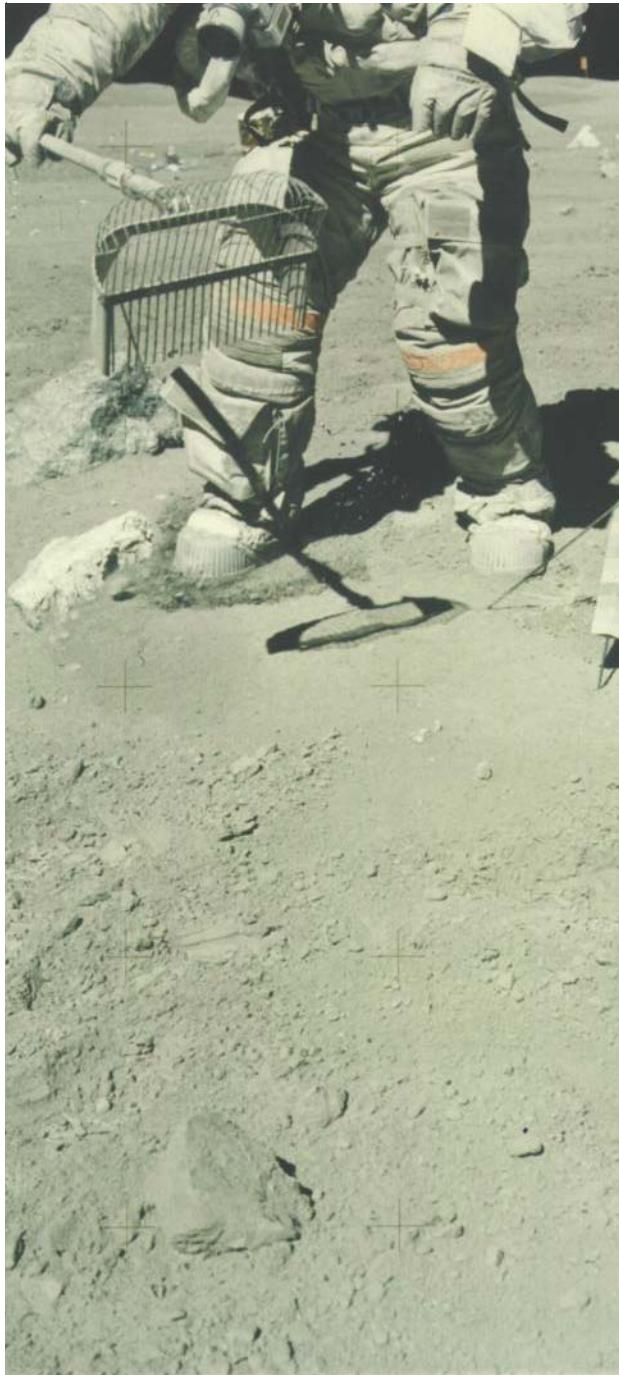


Figure 9: Getting ready to rake for sample 60510. AS16-117-18826. (from old faded photo)

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